CONCEPT NOTE

Project Title: Therma-AI-DATA: Physics-Informed AI and CFD-Driven Thermal Management for Sustainable Data Centres

Call Reference: HORIZON-CL4-2027-04-DATA-09 (Energy efficiency and sustainability of AI data processing in Data Centres)
Type of Action: HORIZON Innovation Actions (IA)
Target TRL Bridge: Moving from TRL 6–7 to TRL 8

Proposer: Prof. Dr. Barış GÜREL
Core Expertise: Advanced 3D Computational Fluid Dynamics (CFD), Multi-Scale Thermal Management, Direct-to-Silicon Microfluidic Cooling, Physics-Informed Neural Networks (PINN), Bio-Inspired Heat Exchangers.
Institution: Suleyman Demirel University, Department of Mechanical Engineering, Energy Division, Türkiye
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Dear Potential Coordinator,

In response to the HORIZON-CL4-2027-04-DATA-09 call, I offer a concrete, physics-driven, CFD-optimized, and experimentally validated thermal management framework to drastically reduce the cooling energy overhead of dense AI workloads. As industrial computing transitions from external cold plates to direct-to-silicon microfluidic cooling to handle severe thermal ceiling crises, our specialized expertise provides a flawless technical foundation for your consortium. Every task proposed below directly maps onto my registered patents, completed TÜBİTAK projects, and high-impact international publications.

1. MY CORE WP CONTRIBUTIONS & LOGICAL LINK TO PAST R&D OUTPUTS

I am prepared to take ownership of specific technical tasks, leveraging a proven academic and applied track record to guarantee successful execution within your Work Packages:

- Task A: On-Chip Microfluidic & Direct-to-Silicon Cooling Architecture Design
  The Task: Performing high-resolution 3D CFD analysis and shape optimization for direct-to-silicon cooling micro-channels and bio-inspired micro-grooves to dissipate extreme heat fluxes on next-gen AI hardware.
  The Track Record: This task builds directly upon my extensive research on advanced heat transfer, additive manufacturing (Selective Laser Sintering) for micro-thermal systems, and bio-inspired (lung and sharkskin patterned) surface geometries designed to reduce fluidic friction, minimize pumping power, and clear localized hotspots.
  The Commitment: This task will be fully executed by utilizing the extensive experience, technical know-how, and R&D background gained from these past academic publications, registered compact heat exchanger patents, and additive manufacturing projects.
- Task B: Multiphase Modeling for Phase-Change and Immersion Systems
  The Task: Running advanced multiphase simulations to optimize fluid phase-change dynamics, dielectric flow circulation, and bubble removal in next-generation immersion cooling tanks.
  The Track Record: Supported by my registered international patent US12397470B2 ("Compact combustion chamber mold for a circulating fluidized bed boiler"), I possess a deep understanding of fluidization, multiphase flow dynamics, and complex boiling/evaporation mechanics under severe conditions.
  The Commitment: This task will be fully executed by utilizing the extensive experience and technical know-how gained from these past registered international patents and multi-phase fluid dynamic modeling projects.
- Task C: Physics-Informed Neural Networks (PINN) for Real-Time Thermal Forecasting
  The Task: Developing ultra-lightweight, real-time Digital Twins that embed physical boundary constraints to safely predict thermal state changes and allow safe overclocking during spiky AI workloads.

The Track Record: Moving away from computationally heavy black-box AI, I will embed fundamental thermodynamic laws (Fourier's law and Navier-Stokes equations) directly into deep learning loss functions, building upon my established experience in utilizing artificial neural networks (ANN) for thermal systems tracking and transient state monitoring.
The Commitment: This task will be fully executed by utilizing the extensive experience and modeling know-how gained from these past neural network integrations and advanced thermal simulation projects.

- Task D: Waste Heat Capture and Circular Energy Integration
The Task: Modeling the thermodynamic integration and exergy loops needed to capture high-grade reject heat (>70°C) unlocked by embedded microfluidic arrays and efficiently redirect it to local district heating or agricultural greenhouse infrastructures.
The Track Record: This maps directly onto my award-winning patent TR 2022/021642 A ("Kalsine edilmiş yumurta kabuğuyla baca gazındaki karbondioksiti kalsiyum karbonata dönüştürme yöntemi"), green campus energy feasibility studies, and multiple TÜBİTAK projects focused on industrial thermal process integration and emission capture.
The Commitment: This task will be fully executed by utilizing the extensive experience and know-how gained from these past patents, environmental-thermal integration publications, and multi-partner R&D projects.
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2. BRIDGING THE TRL 6-7 TO TRL 8 GAP (EXPERIMENTAL VALIDATION)

As an Innovation Action (IA), this call demands a clear, low-risk pathway to market-readiness. At Suleyman Demirel University, we house advanced thermal characterization, flow visualization, and physical prototyping laboratories. We will use this internal infrastructure to physically validate the virtual CFD models under simulated extreme computing loads. This strategic bridge effectively minimizes physical deployment risks and layout failures before the liquid-cooling and machine learning technologies are scaled up at the consortium's industrial demonstration site.

3. STRATEGIC VALUE TO THE CONSORTIUM

By onboarding my team, the consortium secures three immediate benefits to guarantee a winning proposal:

1. Scientific Depth for the "Excellence" Section: My record of 50+ international journal publications and editorial roles ensures that the physical foundations of the cooling architectures are flawless, maximizing evaluation scores.
2. Virtual Prototyping and De-risking: Running advanced 3D CFD simulations allows the consortium to test hundreds of cold-plate and fluid-flow variants virtually under extreme workloads, avoiding costly hardware manufacturing defects.
3. Verifiable Metrics: I will track PUE (Power Usage Effectiveness) optimization and exergy efficiency scientifically, rendering the proposal's "Impact" section robust and bulletproof against evaluator scrutiny.

IN CONCLUSION: HORIZON-CL4-2027-04-DATA-09 demands a paradigm shift where AI infrastructure is optimized through rigorous physical laws. With registered thermal patents, extensive CFD experience, and advanced PINN methodologies, I am ready to provide the scientific backbone your proposal needs.

I look forward to discussing how we can integrate into your Work Packages.

Sincerely,

Prof. Dr. Barış GÜREL
Head of Energy Division, Suleyman Demirel University, Türkiye